sion through the earth's atmosphere, he computed that twenty-seven thousand million million candles must be spread over the moon's earthward hemisphere, painted black, to send us as much light as we receive from her. Probably forty thousand million million candles would be required to allow for absorption. Sir William carried his computations a little farther, and figured, that, if the face of the moon which we see were painted black, and covered with candles standing packed in square order, touching one another, all burning normally, the light received at the earth would be about the same in quantity (as estimated by our eyes) as it really is.

How does moonlight compare with sunlight? On the 8th of December, 1882, Sir William Thomson in Glasgow measured the brilliancy of the sunlight at one P.M., and computed that it was about fifty-three thousand times greater than that of a candle-flame. This, he says, is more than three times the value found by Arago for the intensity of the sun's light. 'So much for a Glasgow December sun!' Hence he derived the conclusions that the Glasgow sunlight was seventy-one thousand times the York moonlight, and that "we cannot be *very far* wrong in estimating the light of full moon as about a seventy-thousandth of the sunlight anywhere on the earth." Those who are curious to know more of this inquiry will find the note to which we call attention in the proceedings of the Glasgow philosophical society for 1882–83.

LETTERS TO THE EDITOR.

**** Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.*

The oldest living type of vertebrates.

I WAS gratified to have my own conclusions as to the systematic relations of the galeoid Selachians verified by so competent an original investigator as Mr. Garman. The differences between us now are fictitious rather than real; or better, perhaps, they are chiefly differences of expression.

As to the characters of the Opistharthri, it must be remembered that I assigned them long before Chlamydoselachus was known; and then the statement that among living sharks they 'alone exhibit' the 'peculiarities' specified, was literally true.

'The palato-quadrate, not articulated with the skull,' is a true character of the typical sharks and Rhinae. Of course the apparatus, being the suspensorium of the lower jaw, must have *some* connection with the cranium; but it is indirect, and not direct. The name 'Anarthri' is therefore quite appropriate, contrasting well with 'Opistharthri' and 'Proarthri.' The newly proposed term, 'Mesarthri,' is, however, unobjectionable, although I should still, independent of priority, prefer Anarthri. No one who took an intelligent interest in the subjects in question would be misled by the name 'Anarthri,' or the diagnoses of the Anarthri and Rhinae.

I must dissent from the opinion that the Cladodontidae are related to the Chlamydoselachidae rather than to the Hybodontidae. To traverse the question would, however, infringe too much on your space.

Mr. Garman, in his substitute for my provisional diagnosis of the Selachophichthyoidei, 'vertebral condition unknown,' has added to our knowledge of the group by verifying my suggestion (*Science*, April 11, 1884) that the "anatomy will probably reveal a structure most like that of the Opistharthri."

I am pleased to find that the views of Mr. Garman as to the remoteness of the Xenacanthini or Ichthyolomi from the true selachians agree with those expressed by myself. The Xenacanthini, in fact, appear to me to be true fishes rather than selachians, although not teleosts, as has lately been urged.

THEO. GILL.

Hornblende andesite from the new Bogosloff volcano.

A short time since, there were received at the National museum, from Lieut. George M. Stoney of the Ounalaska, several fragments of rock from the new volcano on Bogosloff Island in Bering Sea. On account of the interest just now attached to this locality, it is thought a brief notice of these may not be out of place here.

The rocks are hornblende andesites. Two varieties were received, — one very light gray and slightly purplish in color, fine-grained, friable, and somewhat porous; the other dark gray in color, and much more firm and compact in texture; both varieties containing macroscopic hornblende and plagioclase, and, under the microscope, seen to be nearly identical, each consisting of a gray groundmass in which are embedded deep reddish-brown, strongly dichroic hornblendes, light green augites, and numerous crystals of a plagioclase felspar. Sanidin is also present, a very little apatite, and the usual sprinkling of iron oxides, which seem to be largely magnetite. The groundmass consists of a microfelsitic base, carrying colorless microlites, grains of opacite, and minute yellowish and greenish particles which are probably hornblende and augite. The light-colored variety contains small patches of a nearly colorless glass, while the dark variety seems felsitic throughout. A more detailed description of these rocks will be given later.

GEO. P. MERRILL.

National museum, Washington,
Dec. 1.

Edison's three-wire system of distribution.

Referring to the article with the above heading in No. 94 of *Science* (Nov. 21), it is not difficult to show that the conclusions reached are not in harmony with the fundamental proposition governing the size of electric conductors. This proposition is, that "the additional running-expense due to the resistance of the conductor shall equal the interest on

its first cost." The correctness of the principle has been established by Sir William Thomson and others.[1]

In the three-wire system, Edison reduces the current to one-half its value in the two-wire system, and increases the total resistance of the same number of lamps to four times the former value, by the arrangement shown in the second diagram of the article referred to. The total heat-energy developed in the lamps, then, remains the same, since it is represented by C^2r, where r is the combined resistance of the lamps in multiple arc. The inference is, that the resistance of the leading wires should also be increased fourfold. In the articles referred to at the bottom of the page; it is shown that the cross-section of the conductor should vary simply as the current strength. Hence the conductors in Edison's three-wire system should be diminished only one-half in size for greatest economy of working. That this is entirely correct will appear from an examination of the energy expended in heating the leading wires in the several cases. In the two-wire system

$$C = \frac{E}{R + r}, \tag{1}$$

in which R and r are the resistance of conductors and lamps respectively. In the three-wire system as arranged by Edison

$$\tfrac{1}{2}C = \frac{2E}{4R + 4r}. \tag{2}$$

In the three-wire system, with conductors half size,

$$\tfrac{1}{2}C = \frac{2E'}{2R + 4r}, \tag{3}$$

in which E' equals the electromotive force of each of the two dynamos in series. This electromotive force can be lower than in cases one and two. From (1), $E = CR + Cr$, and $EC = C^2R + C^2r$, for total electrical energy expended; the first term being the heat-waste in the conductors, and the second the energy expended in the lamps.

From (2), $E = CR + Cr$, as before. The total energy is $\frac{1}{2}C \,.\, 2E = CE$, the same as before. From (3), $E' = \frac{1}{2}CR + Cr$, and the total electrical energy is $\frac{1}{2}C \,.\, 2E' = CE' = \frac{1}{2}C^2R + C^2r$. The energy expended upon the lamps is the same in the three cases, being represented by C^2r; but in the third case the heat-waste is $\frac{1}{2}C^2R$, or only one-half as much as in the other cases. In Edison's arrangement the ratio between energy expended in the lamps, and heat-waste in the mains, is the same in his three-wire system as in the two-wire system. If the conductors be reduced to only half their former cross-section, the ratio of heat expended in conductors to heat developed in lamps is only half as great as before. Edison saves 62.5% of the cost of conductors, or 62.5% of the interest on their cost, the running-expenses remaining the same. With half-size conductors, the saving would be 25% in interest on cost of conductors, and 50% in heat-waste on conductors, or a total of 75%, — a gain of 12.5% over the plan adopted by Edison. Moreover, the electromotive force of each machine being lower, the dynamos could be reduced in size, and their cost would be less. In reducing the conductors three-fourths in cross-section, the rise of temperature for the same quantity of heat developed in them is four times as great as in the two-wire system, since their capacity for heat is reduced to one-fourth. In the case of conductors reduced one-half in size, the rise of temperature would be the same as with the two-wire plan, since the energy expended in heating them is one-half, and their thermal capacity is also one-half. We have supposed, in the calculated economy, that the three wires are all of the same size. Their combined cross-section would then be $\frac{3}{2} \,.\, \frac{1}{2} = \frac{3}{4}$ of the combined cross-section of the two wires in the first plan. The saving in interest on conductors would then be 25%. Edison sacrifices running-expenses in order to diminish the size of his conductors beyond what is clearly the most economical arrangement. We take it for granted that the principle of making loss by heat-waste in conductors equal to interest on their first cost was taken into account in calculating the size of conductors in the two-wire plan.

H. S. CARHART.

Evanston, Ill., Dec. 1.

[1] *Nature*, vol. xxiv. p. 489; *American engineer*, Nov. 7, 1884.

CAN GHOSTS BE INVESTIGATED?

IN the last number of *Science*, Mr. Gurney, honorary secretary of the Society for psychical research, replies to my paper in *Science* of Oct. 17, 1884. To one whose experience has been that scientific discussion is often nugatory because the parties sedulously refuse to understand each other, it is a great pleasure to read Mr. Gurney's paper. The reader who compares it with my own, will, I think, have a fair view of the two sides of the question from the special point of view which we have heretofore taken. I therefore ask permission to consider the subject from a somewhat different standpoint.

When one adduces evidence in favor of telepathy between living persons, each having the other in mind, I am prepared to listen in the spirit of one who feels that there may be many things on earth not yet dreamed of in our philosophy. But when an imposing array of evidence is presented, tending to show telepathy between a live man and a dead one, I must frankly confess that I cannot help receiving it in the spirit of the African monarch of whom the following story is told. He had captured a Dutchman who had been trespassing on his territory, and was about to put him to death. The prisoner, however, like the heroine of the 'Arabian nights,' managed to postpone the fatal day from time to time by inventing stories about the wonders of civilization with which to regale the royal mind. When his inventive powers had reached their limit, he felt obliged to fall back upon facts,